Methane in Great Artesian Basin Aquifers: emission factors for groundwater pumping and coal seam gas produced water

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ABSTRACT: High volumes of groundwater are pumped from aquifers or naturally released through springs or seeps. In the Great Artesian Basin (GAB) various industries, agriculture, feedlots, town water supply, and private landholders extract groundwater. In a component basin, the Surat Basin, coal seam gas (CSG) is also extracted from the Walloon Coal Measures.

Gassy water bores can cause pump locks, and other hazards for landholders. High concentrations of dissolved and free gas have been measured in different GAB aquifers, both above and below the CSG reservoir. For example, deep water bores sampled in the Hutton and Precipice sandstone aquifers contained up to 2100 mg/L dissolved methane. CSG production water measured here contained up to 31 mg/L methane.

Dissolved methane was sampled via several methods, and emission estimates determined using estimated pumped water volumes and measured methane concentrations. New emission factors were determined for groundwater pumping, and for CSG production water. The existing emission factors for CSG production water (used by the Australia government) were taken from a USA emission factor originating from a simulation study. We found it to be an order of magnitude higher than emission factors determined from our Australian data.

We conclude that: 1) Current CSG produced water emission factors may not represent Australian conditions and overestimate emissions.

2) Current standard dissolved methane sampling is not fit for purpose, especially for gassy bores and hot deep groundwaters.

Introduction

- The Surat Basin hosts various industries that extract groundwater including for coal seam gas (CSG), feedlots, town water supply and agriculture. Important aquifers in the Surat Basin study region include the Mooga, Gubbermunda, Springbok, Hutton, and Precipice sandstones, along with the Condamine Alluvium (Figure 1,2). Gas has been observed in some bores drawing groundwater from different aquifers across the basin. Gassy bores may emit methane to the atmosphere.
- CSG gas and production water are extracted in the same area in Queensland, including from the Surat Basin Walloon Coal Measures (Figure 1, 2) (Pearce et al., 2022).
- Methane emissions to the atmosphere may be from multiple sources in the region.

Figure 1: Examples of landholder, town water supply, and monitoring bores, a CSG well, and collecting dissolved gas with a closed method (Isoflask).

Methods

- Groundwater and dissolved gas samples collected from 70 water bores (with a range of installed pumps) bores mainly in the Chinchilla – Dalby region. CSG production water was collected from 6 active production wells (Figure 3).
- Methane concentrations measured at ALS from vial containers, and Stratum Reservoir from Isoflask closed sample containers.
- Annual groundwater volume estimates extracted from different aquifers were sourced from the literature, with CSG production water measured volumes (Figure 5). The calculation of methane emissions followed the methods of previous studies in the UK and USA, using the estimated extracted groundwater volumes and the measured dissolved methane concentrations (Gooddy and Darling, 2005; Kulongoski and McMahon, 2019). Emission estimates were compared using a) vial open sampling method dissolved methane, and b) the closed (Isoflask) method for methane measurement.

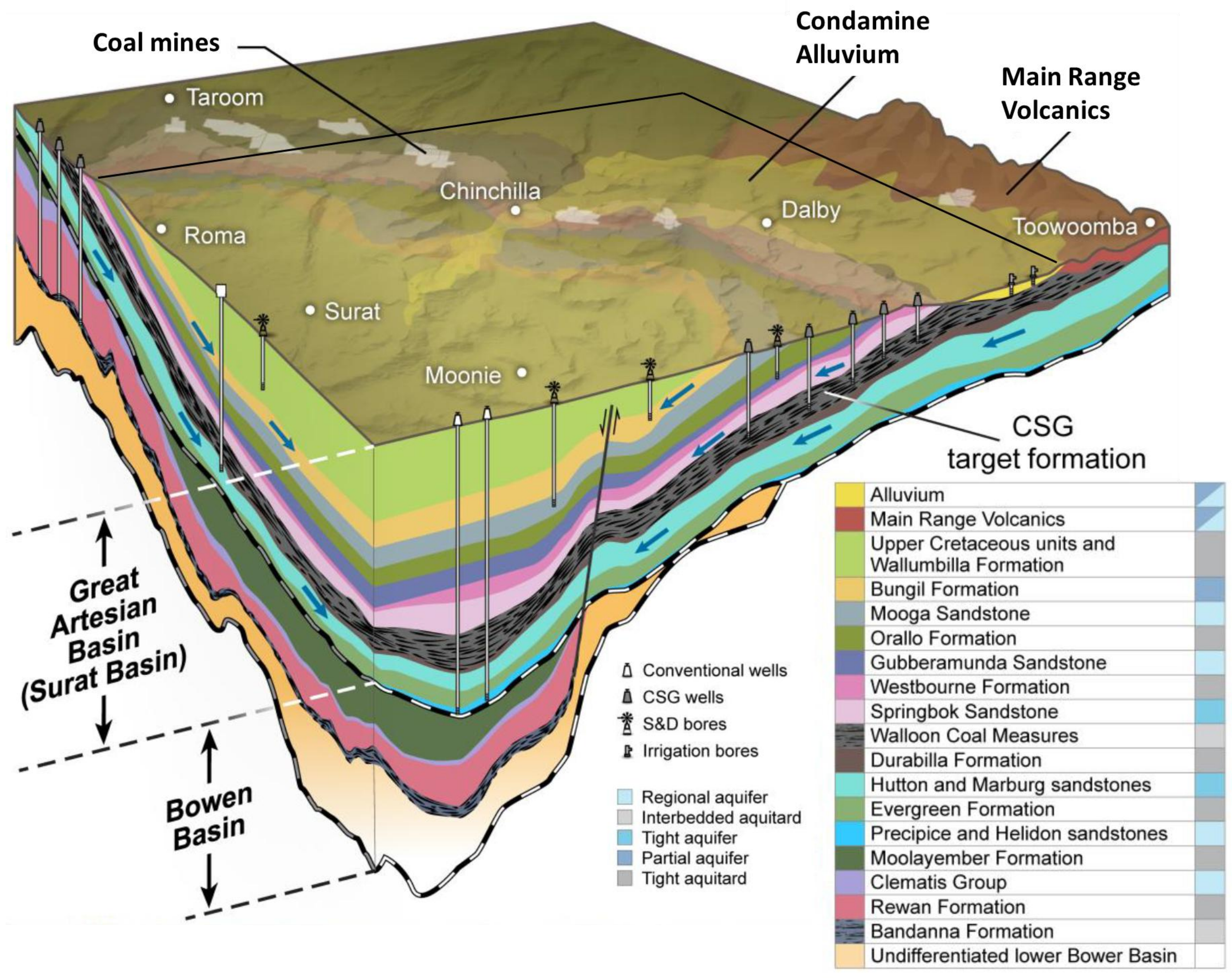

Figure 2: Aquifers of the GAB in the Surat Basin, and the Walloon Coal Measures CSG formation (modified after OGIA 2021).

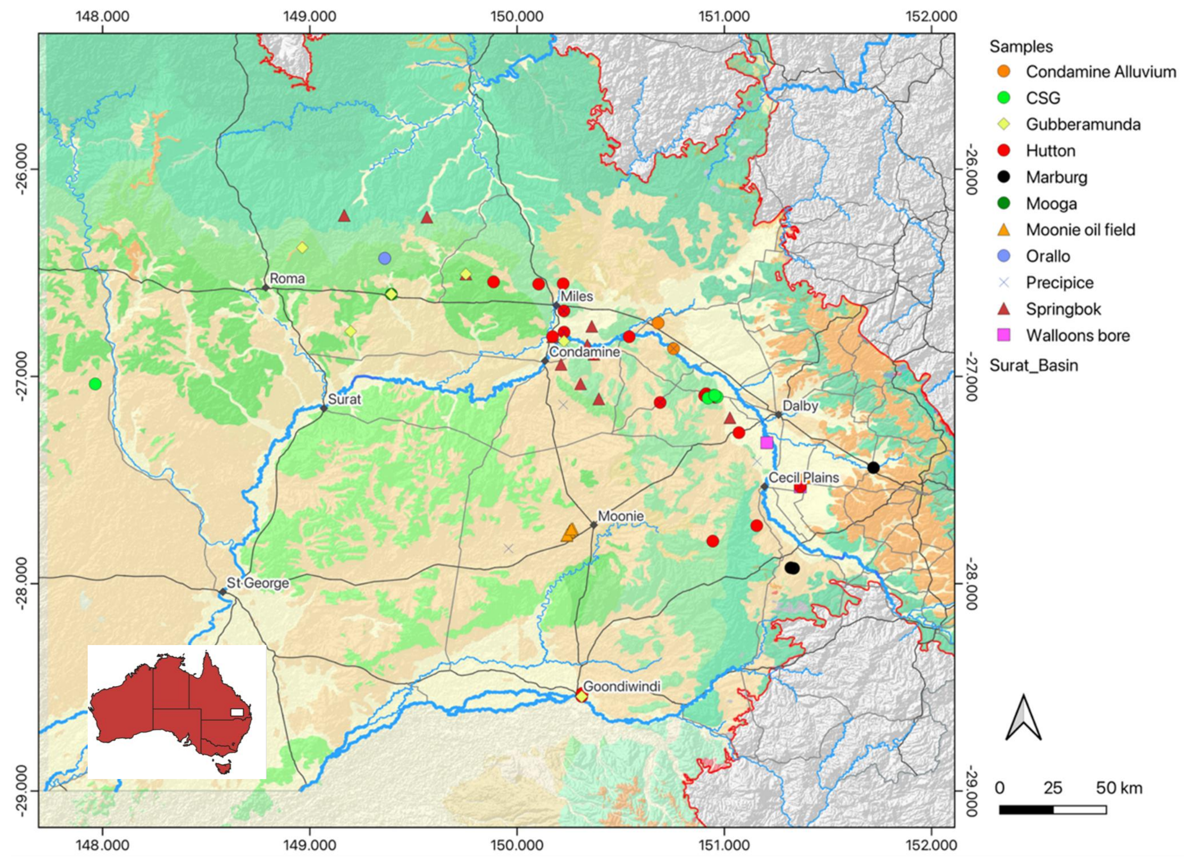

Figure 3: Map of the sampled bores and wells, note many bores are nested.

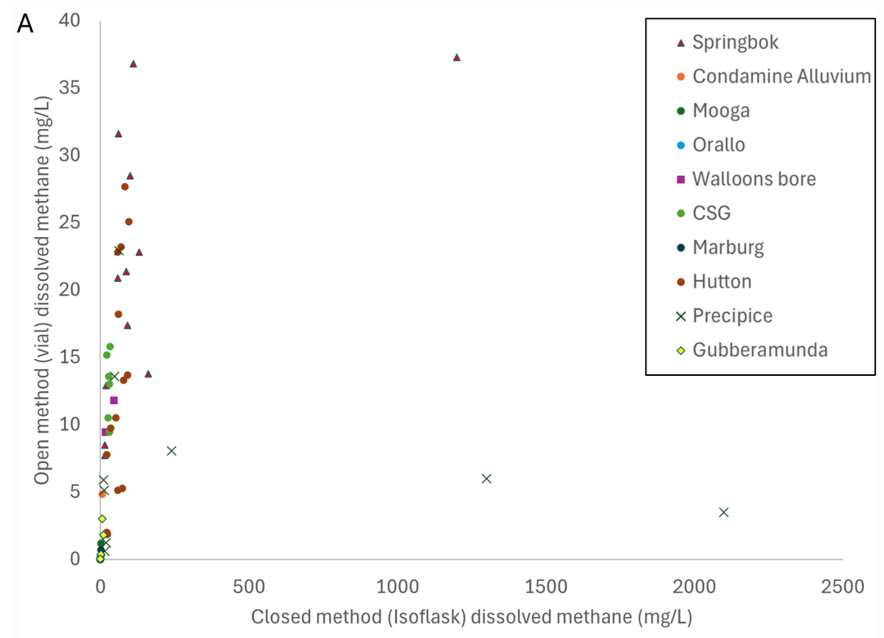

Figure 4: Dissolved methane concentrations (mg/L) measured from different formations using the closed (Isoflask) and open (Vial) sampling methods. Note the different axis scales.

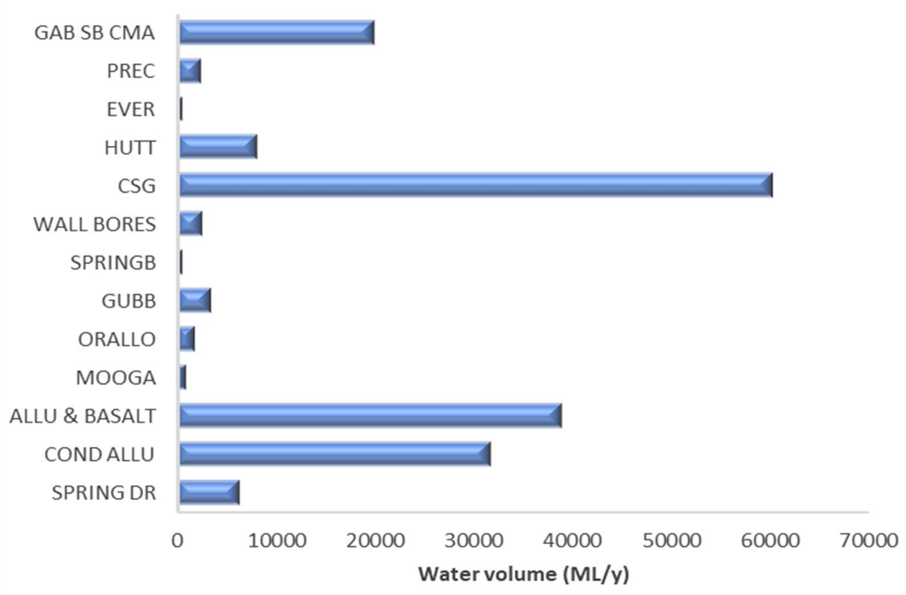

Figure 5: Estimated extracted annual water volumes in the Surat Basin Cumulative Management Area based on (OGIA 2021).

Results

- Methane concentrations measured from Isoflask containers were significantly higher than from vial sampling, especially in gassy bores of the Precipice Sandstone and Springbok Sandstone aquifers (Figure 4, 6).
- This is owing to degassing of methane during the sampling process when pressurised gas in waters is pumped out, contacts the atmosphere and then is open filled in standard vial containers. This degassed methane component is emitted to the atmosphere during sampling.
- The *total* calculated methane emissions are significantly different with the different methods used (Figure 7).

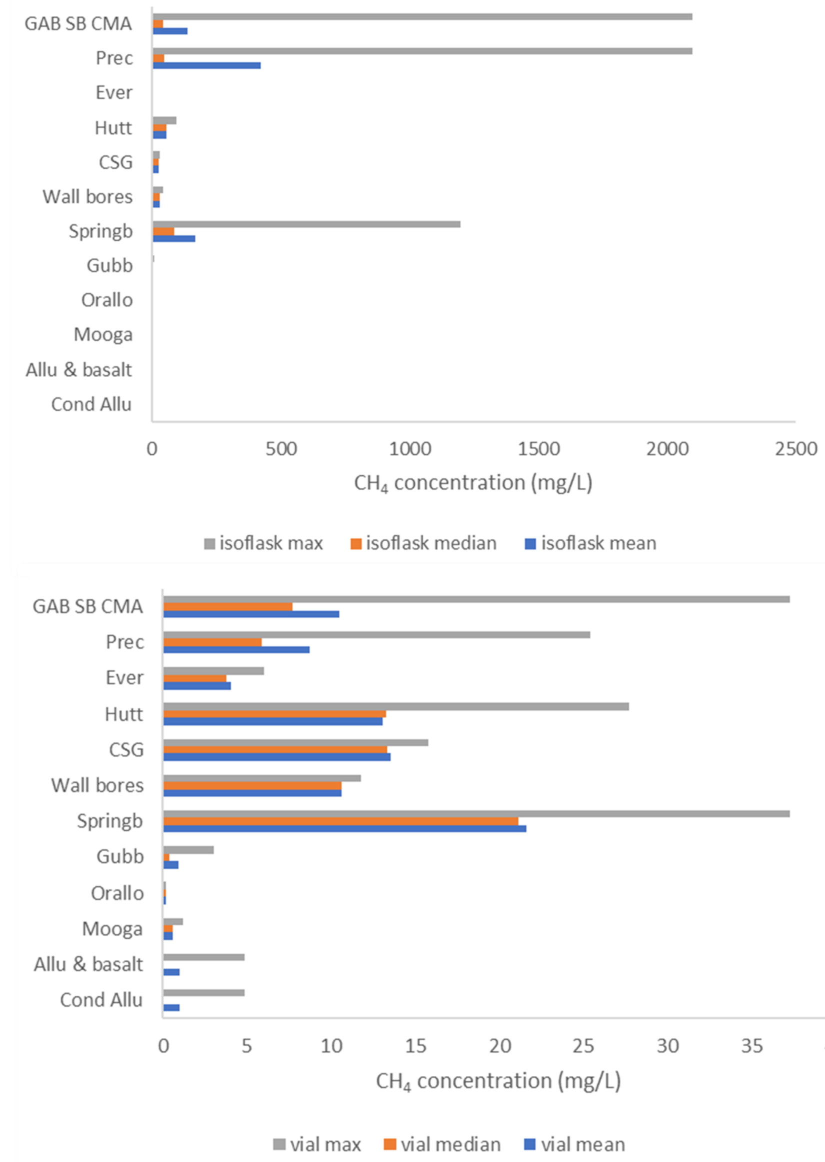

Figure 6: Maximum, median and mean methane concentrations (mg/L) measured in different aquifers and CSG production waters. Top: from Isoflask closed sampling; bottom: from vial open sampling, note the very different concentration scales.

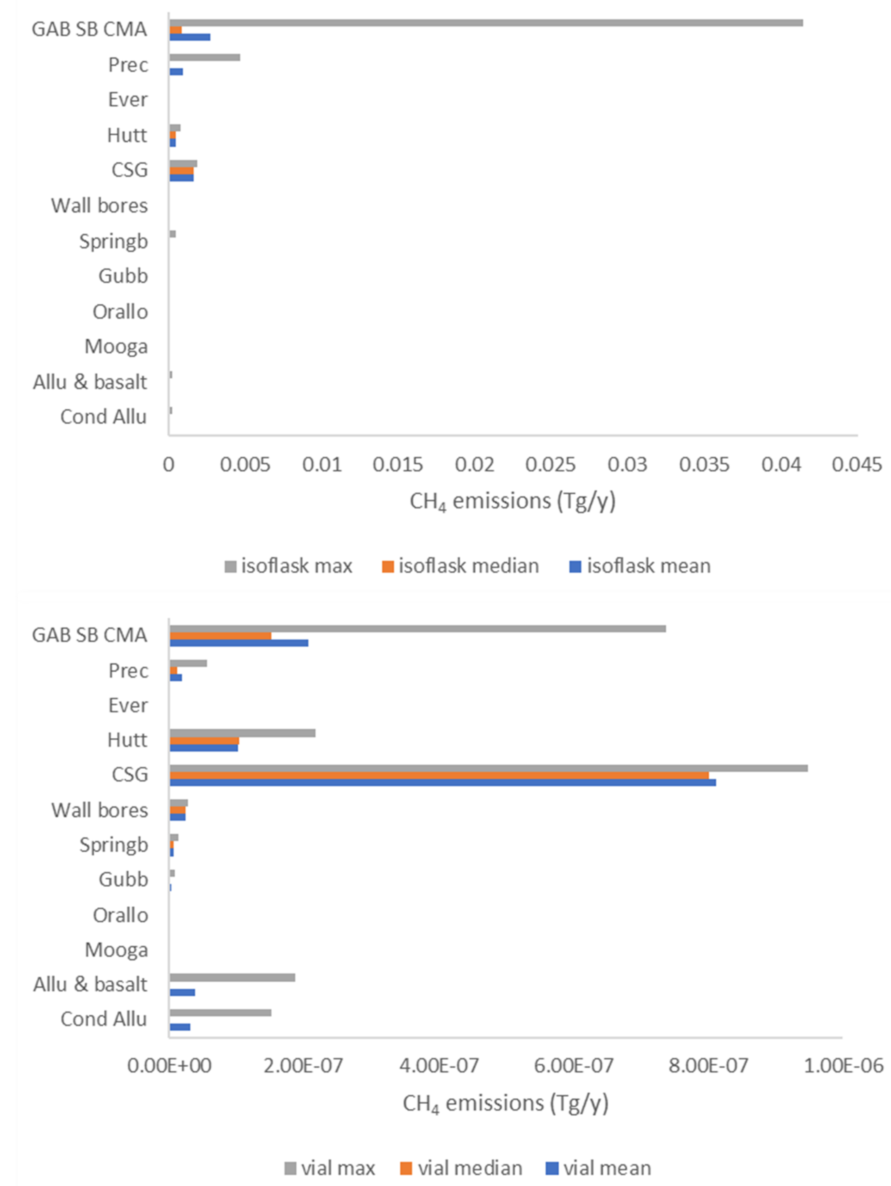

Figure 7: Methane emission estimates (maximum, median and mean), top: calculated using the closed sampling Isoflask measurements; bottom: using the open sampling vial methane concentration measurements. Note the much larger scale on the top plot.

Conclusions

- Our more accurately measured dissolved methane concentrations from the closed Isoflask sampling, give a maximum methane emission factor for the CSG production water of 0.031 kg/m^3 (or tonnes/ML).
- The currently used emission factor in Australia is an order of magnitude higher 0.31955 kg/m^3 (tonnes/ML) (Australian Government, 2020). That currently used emission factor originated from a USA based simulation study.
- While more data is needed in Australia, this suggests the current emissions from Australian CSG production water are being *overestimated*.
- Our data for gassy deep GAB aquifers gives a maximum methane emission factor of up to 2.1 kg/m^3 (tonnes/ML)
- The currently used CSG produced water emission factors may not represent Australian conditions and overestimate CSG production water emissions. New data are needed from CSG production waters across a range of fields for more robust emission factors.

Suggested Future Work

A study of the dissolved methane actually measured using closed methods from CSG production waters in a wide range of CSG reservoirs and different fields is needed to improve methane emission factors.

Substantial volumes of groundwater are pumped or released via springs and artesian uncapped bores. While methane concentrations will vary, little is known about the concentrations emitted across Australia or how they overlap with emissions from other sources.

Pearce et al., 2022. Methane in aquifers and alluvium overlying a coal seam gas region: Gas concentrations and isotopic differentiation, Science of the Total Environment https://doi.org/10.1016/j.scitotenv.2022.160639

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